The W. Averell Harriman School
for Management and Policy

Master Thesis

AN ANALYSIS AND VALUATION OF AMERICAN SUPERCONDUCTOR CORPORATION

By

Wolfram Fischer

Presented in Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE

in

Management and Policy

State University of New York
at
Stony Brook

Professor Gerrit Wolf, Advisor

15 December 2000

CONTENTS

LIST OF EXHIBITS

1. ABSTRACT

American Superconductor Corporation develops and manufactures high-temperature superconductor equipment for the electric power industry. High-temperature superconductors, a new technology, allow the loss-free transmission of electric current under reasonable cooling requirements. With the deregulation of electricity markets and increasing environmental concerns, the company operates in a rapidly changing business environment. The prospects of American Superconductor's products are reviewed and, using M. Porter's Five Forces Model, the company's strategy is analyzed. American Superconductor's products are particularly suited for applications where space and environmental concerns matter. A focus on these needs is therefore the best strategy for the foreseeable future. The company's value is estimated by discounting the future free cash flow. Free cash flow projections are derived from estimated market sizes, market shares and free cash flow margins. Using a risk-free discount rate this gives a company value of approximately $900 million or $45 per share. For risk-adjustment these numbers have to be discounted.

2. EXECUTIVE SUMMARY

- American Superconductor Corporation develops and manufactures high-temperature superconductor equipment for the electric power industry. Such equipment includes power quality products, power cables, motors, generators, and transformers. The report analyzes the prospects and strategy of American Superconductor, and estimates the company value.
- With deregulation of electricity markets and increasing emphasis on environmental concern, the company operates in a rapidly changing business environment.
- The spread of the Internet and the increasing use of digital equipment lead to rising demand for or high quality electric power. This presents a business opportunity for American Superconductor's power quality products. However, due to its price, this equipment can compete only in specialized applications.
- Despite its higher cost, electric power equipment using high-temperature superconductors (power cables, motors, generators, and transformers) is superior to conventional equipment when size and environmental concerns matter.
- By focusing on solutions for a particular set of problems in the electric power industry (power quality, size, environmental concern) American Superconductor has a viable strategy for the foreseeable future.
- Due to the long lifetime for electric power equipment and the substantial resistance of customers to change, it will take many years before a sizable market for high-temperature superconductor power equipment is established.
- Using market estimates for the company's products, estimates for market shares and free cash flow margins, the future free cash flow can be approximated.
- Discounting the future free cash flow, using a risk-free rate, a company value of $900 million or $45 per share is obtained. These figures have to be discounted to adjust for risk.

3. SETTING: AMERICAN SUPERCONDUCTOR

American Superconductor Corporation[1] (ASC) was founded in 1987 to develop and produce high-temperature superconductor products for the electric power industry. It sees it's mission as to "revolutionize the way we use electricity"®. The company's products include superconducting energy storage devices, power cables, motors, generators and transformers.

Superconductivity is an effect in which some materials loose all resistance to electric current when cooled below a certain temperature. Until 1986 only so-called low-temperature superconductors (LTS) were know. These are materials have to be cooled to temperatures near the absolute zero (typically four Kelvin or minus 452 degrees Fahrenheit). In 1986 a new class of superconductors, so-called high-temperature superconductors (HTS), were discovered. The cooling technology for these materials is less complicated and significantly less expensive than for LTS materials. Products using superconducting technology can be smaller, more energy efficient, and more environmentally friendly than conventional equipment. More information on superconductors can be found in Appendix A.

Since its incorporation in 1987 American Superconductor has focused on research and development that leads to HTS products for the electric power industry. So far the company has spent about $100 million in this effort. In 1998 the first product line, superconducting magnetic storage devices (SMES), was commercialized.

The company finances its operations with public share offerings. American Superconductor sought a number of strategic alliances to share the substantial R&D risk. Former and present allies include the Department of Energy, the Electric Power Research Institute (EPRI), Inco Alloys International, Pirelli Cable, Reliance Electric, ABB, and Electricité de France. Company history milestones are listed in Appendix B.

American Superconductor's base products are high-temperature superconducting wires and tapes. These wires and tapes are integrated into components for electric power equipment and into end products. In addition, the company manufactures products related to the production of superconducting power equipment, like cooling systems and power electric converters. Appendix C gives a detailed description of the company's products

There is no established market for superconducting power equipment yet. Such equipment competes with conventional equipment, which is primarily based on copper conductors. Due to its unique performance characteristics, estimates can be made on the potential market size for superconducting power equipment (see Appendix C for more details). These estimates are summarized in Exhibit 1 – American Superconductor products' potential market size.

Exhibit 1 – American Superconductor products' potential market size

Product	Estimated annual market size	Begin commercialization
SC wire	Rarely sold separately	
SC Magnetic Energy Storage (SMES)	$500 million	1997
SC power cables	$5 billion	2001
SC motors	$1 billion	2001
SC generators	$2 billion	later than 2001
SC transformers	$1 billion	later than 2003
Power electronic converters	$1 billion	2000
SC fault current limiters	$300 million	later than 2005
All products	$10.8 billion	

All products, for which the company ultimately plans to manufacture components for, have an estimated annual market of about $11 billions. But only one product, SMES, is currently commercialized and due to the long lifetime of power equipment, it will take 10 to 15 years before a market for all products is established. American Superconductor is now in the process of transforming itself from a pure R&D company to one with significant commercial production.

4. MAIN BODY: ANALYSIS AND VALUATION

4.1. INTRODUCTION

Over many years the generation, distribution and usage of electricity has changed only little. Due to advances in superconductor technology, however, the future may be different. Superconducting products for the electric power industry have the promise of being more energy efficient, smaller and more environmentally friendly than conventional equipment. American Superconductor develops and commercializes such products. The company can offer solutions in a rapidly changing business environment. Due to deregulation the electric power industry is restructuring. Environmental concerns play an increasing role in business decisions, and a steadily rising electricity consumption together with the limits of the existing infrastructure lead to demand for new products and service.
In this work the business prospects of American Superconductor are evaluated and the company value is estimated.

4.1.1. The Technology of Electricity Generation, Distribution and Usage

Most electricity is generated at large power plants, some 15,000 in the U.S.[2] These plants have a typical capacity of several hundred to a few thousand Megawatts and are fueled by oil, gas, coal or nuclear fuel. In all cases the fuel is used to create heat which turns water into steam. The hot pressurized steam drives turbines that, in turn, drive electrical **generators**. Electricity is transported to the users through a grid of **power cables**, either above or under ground. The grid aggregates the electricity supply and demand and makes them more stable. A failing power plant can be replaced by the other power plants in the grid; demand is averaged over many users and therefore also more stable. The distribution grid has several voltage levels. High voltages allow the transportation of electricity with reduced losses, but high voltages are not suitable for generation and consumption due to insulation requirements and safety concerns. Therefore, voltages are increased for transportation over long distances with **transformers**, and reduced again with transformers for usage. In the U.S. about two thirds of the generated electricity is consumed by commercial and industrial users, about one third by residential users (see Exhibit 2 – US Electricity Sales and Prices 1992-1999). The U.S. Department of Energy estimates that **motors** consume 58% of the generated electricity[3].

Electricity is an important part of the industrial production. It is equally important in an information driven business environment where electricity powers the equipment that stores and processes data. With the rising number of computers and sensitive production equipment, there is a growing demand for electricity quality, i.e. the uninterrupted availability of power in a narrow voltage and frequency range.

American Superconductor is developing core components for superconducting power cables, transformers, generators and motors. In addition, the company offers power quality solutions with superconducting magnetic storage devices (SMES). Electric power equipment is expensive and has long life spans of typically 30 years. Technological changes in the electric power industry will therefore take a long time to fully penetrate the market.

Exhibit 2 – US Electricity Sales and Prices 1992-1999[3]

	1992	1993	1994	1995	1996	1997	1998	1999
Sales by sector (TWh)								
... Residential	936	995	1,008	1,043	1,082	1,072	1,132	1,140
... Commercial	761	795	820	863	887	913	950	975
... Industrial	973	977	1,008	1,013	1,030	1,033	1,055	1,050
... Other	93	95	98	95	98	98	100	100
Total sales	2,763	2,861	2,935	3,013	3,098	3,115	3,238	3,265
Revenue by sector ($ millions)								
... Residential	76,848	82,814	84,552	87,610	90,502	90,659	93,510	93,149
... Commercial	58,343	61,521	63,396	66,365	67,825	69,768	70,624	70,191
... Industrial	46,993	47,357	48,069	47,175	47,387	47,126	47,385	46,442
... Other	6,296	6,528	6,689	6,567	6,743	6,727	6,812	6,765
Total revenues	188,480	198,220	202,706	207,717	212,457	214,280	218,331	216,547
Av. revenue by sector (cent/kWh)								
... Residential	8.21	8.32	8.38	8.40	8.36	8.46	8.26	8.17
... Commercial	7.66	7.74	7.73	7.69	7.64	7.64	7.43	7.20
... Industrial	4.83	4.85	4.77	4.66	4.60	4.56	4.49	4.42
... Other	6.74	6.88	6.84	6.88	6.91	6.90	6.79	6.74
Total average	6.82	6.93	6.91	6.89	6.86	6.88	6.74	6.63

4.1.2. The Business Environment for the Electric Power Industry

Utility companies are responsible for the generation and distribution of electricity. Until recently U.S. utilities operated as supply monopolies. They were heavily regulated and shielded from the market forces that companies face in a competitive environment. The restructuring of the electric power industry began after the **deregulation** of electricity markets started. In 1995 California, Connecticut, Vermont and Washington issued the first regulatory orders. As of May 2000, 23 U.S. states have enacted deregulation. In many more states changes are under way, only eight states show no activity so far. Deregulation, ultimately, will allow customers to choose electricity from different providers. The competition is likely to reduce prices in the long run, as it happened in the telecommunication market. Due to the commodity character of electricity, cost leadership will be an important competitive advantage for utilities. But utilities will also try to offer better quality electricity and service with which higher margins can be earned.

So far, experience with deregulated electricity markets has been mixed. With capacity limitations prices in California went considerably up during times of peak demand. And the complicated process of regulatory approval for new power plants makes it unlikely that more generating capacity is added in the short run. Customer experience in Europe, notably Great Britain and Germany, is more positive, largely due to an over-capacity.

Environmental concerns play an increasing role in business decisions in the electric power industry. The public perception of the risks associated with nuclear energy lead to a standstill in the commissioning of new nuclear power plants. Only four nuclear plants have been commissioned in the U.S. in the last decade and none since 1996.

Fossil-fueled electric power plants are a source of air quality problems. One of these problems is acid rain caused by sulfur dioxide (SO_2) and nitrogen oxides (NO_x) **emissions**. To respond to these problems the Clean Air Act Amendments of 1990 enacted a two-phased plan, administered by the U.S. Environmental Protection Agency (EPA) to reduce acid rain in the United States. In Phase I, which runs from 1995 through 1999, 435 generating units, mostly coal fired plants, were required to reduce emissions or be replaced by other plants. Phase II, beginning in 2000, will affect more than 2,000 units.

There is also growing evidence that the use of fossil fuels contributes to the **green house effect**. The most important green house gas is carbon dioxide (CO_2) which is created when coal, oil and gas are burned. The World Meteorological Organization and the United Nations Environment Program established the Intergovernmental Panel on Climate Change (IPCC) to investigate the green house effect. The IPCC concluded that there is discernible evidence that the rise in the global mean surface air temperature (between 0.5 and 1.1ºF since the late 19th century) has been caused by man-made green house emissions. As a result of such findings, more than 160 nations signed the Kyoto Protocol in 1997, in which the developed nations agreed to limit their green house gas emissions. The United States agreed to reduce emissions from 1990 levels by 7 percent during the period 2008 to 2012[4]. To meet its commitments under the Kyoto Protocol, the U.S. Government pursues a number of initiatives. The Administration's fiscal year 2000 budget request included more than $4 billion in programs related to climate change, including funding for proposed tax incentives, research and development and other spending for the government's Climate Change Technology Initiative (CCTI)[5]. The large-scale use of superconducting materials would contribute to the reduction of green house gases.

4.1.3. Existing Problems in the Electric Power Industry, Solutions and Trends

Worldwide demand for electricity is rising (see Exhibit 3 – World Electricity Consumption by Region 1990-2020E). The U.S. Energy Information Agency (EIA) estimates a compound annual growth rate (CAGR) of 2.5% for the period 1996-2020. The domestic U.S. consumption is expected to grow slower but steadily by 1.2% annually in the same period.

Exhibit 3 – World Electricity Consumption by Region 1990-2020E[6]

Terawatt Hours (TWh)	1990	1996	2000E	2005E	2010E	2015E	2020E	CAGR 1996-2020E
Industrialized countries	6,248	7,194	7,529	8,298	9,001	9,749	10,458	1.6%
… of which US	2,713	3,243	3,333	3,585	3,843	4,113	4,345	1.2%
Eastern Europe/ Former Soviet Union	1,908	1,535	1,396	1,536	1,673	1,813	1,965	1.0%
Developing countries	2,274	3,324	3,895	5,033	6,282	7,695	9,422	4.4%
Total world	10,430	12,053	12,820	14,867	16,956	19,257	21,845	2.5%

The capacity of the power grid remained almost unchanged in recent years and with growing demand power delivery becomes vulnerable[7]. This became apparent with the blackouts in Chicago and New York during the summer of 1999. The grid limitations lead to power disturbances that are estimated to cost U.S. customers $30 billion annually[8].

Furthermore, the electric infrastructure will be seriously challenged to keep up with the demands of the information age. Currently, about 10% of the electricity is consumed by digital applications, a number likely to rise to 30-50% in the next decades with the spread of the Internet and related applications. While it is sufficient to have a 99.9% reliability (or 8 hours downtime per year) for applications like motors, microprocessors may require reliabilities like 99.9999% (or 30 seconds downtime per year) and protective equipment for the remaining downtime[9].

The grid limitations can be overcome by several means. First, small power plants can be erected where electricity is needed thereby reducing the strain on the power grid. In fact, order numbers for 1 MW generation units (this is small to the typical 1,000MW power plants) grow at an compound annual growth rate of 32%[5]. Second, the grid capacity can be increased, for example through wide-area power flow control, advanced power electronics, and **superconducting transmission**. Third, equipment at the customer site can provide back-up energy for power dips. Such equipment includes un-interuptable power supplies (UPS), flywheels and **superconducting magnetic energy storage** (SMES) units.

4.2. Methodology: Strategy Analysis

The analysis of American Superconductor's competitive position and strategy is based on Michael Porter's Five Forces Model[10]. These forces are

- The threat of new entrants
- The bargaining power of suppliers
- Threats from substitute products or services
- The bargaining power of buyers and
- The rivalry amongst existing firms.

To be successful in a competitive environment Porter recommends three generic strategies:

- Cost leadership,
- Differentiation, and
- Focus on niches.

Strategies in the middle are often problematic. Each of the five forces will be discussed in detail. Based on this discussion the company's current strategy is reviewed.

4.3. METHODOLOGY: VALUATION

The company valuation is based on discounted free cash flow estimates according to[11]

$$NPV = \sum_{i=1}^{n} \frac{FCF_i}{(1+r)^i},$$

where *NPV* denotes the Net Present Value, *FCF* the Free Cash Flow and *r* a discount rate. Future free cash flows are estimated from multiplying the estimated market size with an estimated market share and a free cash flow margin. The used free cash flow margin is obtained by comparison with long-term margins of other companies like IBM and Intel. The discount rate used in the valuation is a rate close to the rate on 30-year U.S. Treasury bonds, i.e. a risk free rate. The obtained *NPV* is therefore not risk-adjusted. A per share value is obtained by dividing the *NPV* of the company by the number of outstanding shares.

For risk adjustment a margin of safety is advised, i.e. due to the uncertainties in the valuation process the security should only be bought at a discount. This concept was put forward first by Benjamin Graham[12,13]. Further information on the margin of safety can be found in Warren Buffet's Letters to the shareholders of Berkshire Hathaway[14]. Since American Superconductor is still largely a R&D company that faces a number of large risks on its way to profitability, a discount to adjust for these risk must be substantial.

4.4. RESULTS: THE COMPANY'S STRATEGY

American Superconductor's industry is the electric power industry. This is a mature industry with a few dominating companies. Among these are General Electric[15] and Southwire[16] in the U.S., BICC[17], Siemens[24], ABB[18], and Alcatel Alsthom[19], in Europe, and Sumitomo Electric[20] in Japan. American Superconductor is primarily a supplier to the original equipment manufacturers (OEMs) in the industry.

4.4.1. The Threat of New Entrants

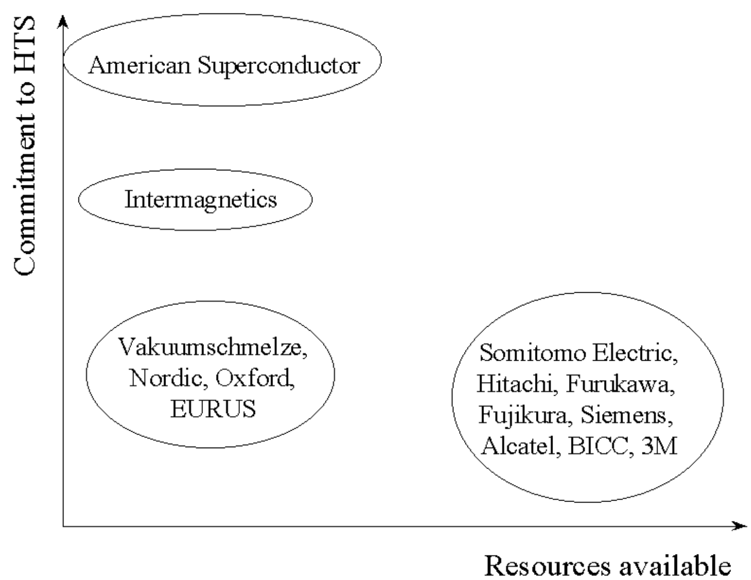
Superconductor technology for the electric power industry is a new field with most products still in the R&D phase. There are only a few active companies world wide. The technology to produce HTS products is proprietary or protected by patents in most cases. The patent protection may last for many more years, but as the technology evolves, patents may become worthless when they cover an obsolete material or process.

New entrants face substantial hurdles. Since successful technology is often patent-protected these companies may not be able to acquire the technology at all or not at commercially viable terms. If a new entrant embarks on its own R&D program, a substantial amount of money and time has to be spent. Even if material and process patents can be obtained, it is likely that a company has to go through a lengthy experience curve before a commercial product can be manufactured. More than 10 years have passed since the discovery of high-temperature superconductivity, and commercial products are still rare.

The largest threat comes from companies that are active in HTS R&D already, but have no near-term plans of commercialization. These companies have access to some patents and may have accumulated enough knowledge to begin a commercialization program. Often theses are large power equipment producers with substantial financial strength. Potential entrants include Japanese companies like Sumitomo Electric Industries[20], Hitachi[21], Furukawa[22] and Fujikura[23]; European companies like Siemens[24], Vacuumschmelze[25], Nordic Superconductor Technologies[26], Alcatel Alsthom[19], BICC[17] and Oxford Instruments[27]; and U.S. companies such as 3M[28], Intermagnetics General[29] and EURUS

Technologies[30]. The situation is shown in Exhibit 4 – American Superconductor's competitive position.

Exhibit 4 – American Superconductor's competitive position



4.3.1. The Bargaining Power of Suppliers

There are four main supplies the company must acquire to be successful: people, patents, raw materials and equipment.

The commercial application of HTS material is a relatively small field and experts are rare. The company is therefore rather dependent on its current employees. If American Superconductor were to loose a number of key employees like CEO Yurek and Chief Technical Officer Malozemoff, its future would be very much in doubt. However, key employees are also large shareholders of the company and it is therefore less likely that they will leave.

Another large risk is the inaccessibility of certain patent protected technology. The company does not engage in materials research and must obtain patents on commercially viable terms to be successful. If a competitor owns a patent that allows producing a competing product with a much better price-performance ratio than ASC, the company may not be able to compete. ASC holds about 200 patents. In addition, it has agreements with Lucent Technology, MIT and Oak Ridge National Laboratory, giving it a mostly non-exclusive access to the HTS patent portfolios of these institutions.

However, ASC's competitor Intermagnetics General holds certain right to a second generation HTS wire manufacturing technology called IBAD (Ion Beam Assisted Deposition). Should this technology allow the production of HTS wire at substantially lower cost than the technology employed by American Superconductor, ASC's products will be less competitive.

For the production of HTS wire some rare metals like bismuth and strontium are needed. The HTS material is embedded in a silver matrix. There is currently no indication, that any of these materials can not be obtained in the quantities needed.

The equipment that American Superconductor uses for its wire production is very similar to conventional wire production equipment. There should be therefore no difficulty in obtaining production equipment.

4.3.2. Threats from Substitute Products and Services

SMES competes with other solutions in existence or under development. HTS products compete primarily with existing products, i.e. conventional equipment for the electric power industry.

Superconducting Magnetic Energy Storage (SMES) units are used to ride through temporary voltage dips. They compete with other devices that provide the same functionality. These include (see Exhibit 5 – Comparison of different electricity quality products):

- Uninterruptable power supplies (UPS), based on batteries
- Flywheels
- Dynamic voltage restorers, based on batteries or capacitors

Lead-acid batteries are still the cheapest way of storing energy, so that solutions based on these batteries (UPS, dynamic voltage restorers) can be very price competitive. However, batteries need one hour or more for a discharge-charge cycle and the battery lifetime is limited to only about 1,000 cycles.

Flywheels have cycle times of one second to 10 minutes and have practically no limit on the discharge-charge cycles they survive. Unlimited cycle numbers are also possible for SMES and capacitors. While SMES units have cycle times of about one second, capacitors are suited for cycle times below 0.1 seconds.

Exhibit 5 – Comparison of different electricity quality products

	Buffer Time	Stored energy [MJ]	Power rating [kVA]	Price	Companies, organizations
SMES	Seconds	~1-5	up to 8000	~$1m/MJ	ASC, IGC, Accel
UPS	Minutes	~1-10	20-1500	~$1k/MJ	Piller, Acumentrics
Flywheels	Minutes	~1-10	150-1300	higher than battery	Piller, Tribology, Acumentrics, Oak Ridge National Lab., Urenco, Active Power
Dynamic voltage restorer	Seconds	~1	40-110	higher than battery	Siemens

While costs for SMES units are currently higher than for the wide spread battery-UPS its strength lies in shorter and unlimited duty cycles, and environmental friendliness. Unless cost can be cut considerably, the addressable power quality market will be only a fraction of the estimated $500 million annually. SMES will compete primarily with flywheels and dynamic voltage restorers in this segment.

HTS power cables, motors and generators and transformers are substitutes for conventional power equipment. These products compete with conventional technology in the following dimensions:

- Manufacturing costs
- Installation costs
- Operating costs
- Environmental costs

The manufacturing cost has two important components: the cost of the superconducting wire and the cost of assembly. Currently the cost of the HTS wire is still substantially higher than the cost of copper wire. Assembly costs for HTS products are increased since cooling equipment is needed. However, most conventional power equipment also needs oil cooling. For motors, generators, and transformers there are potential cost savings in the assembly since the size of the HTS products is only half the size of conventional equipment. The smaller size of these products will also reduce the installation costs since less floor space is needed, structural requirements at the installation site are less stringent and transportation is easier. Through the higher current density of power cables, existing ducts can be used which may substantially reduce installation costs.

With the current in superconductors flowing without resistance, the operating efficiency of all power products increases; typically electric losses are halved. For large power equipment, the reduction of these small losses can add up, especially when energy prices keep rising.

HTS equipment has a great advantage in terms of environmental costs. The typical cooling medium is liquid nitrogen, a non-toxic fluid that can be produced by air liquefaction at a cost that is lower than for a comparable oil volume used in conventional equipment. In addition, the reduced electric losses dampen the green house effects.

4.3.3. The Bargaining Power of Buyers

Currently American Superconductor's buyers have a powerful position. Since sales are quite low, any purchase is large relative to the ASC's total sale. A SMES unit sells at about $0.5 to $1 million and only about 10 units are sold annually at the moment. Since the product is not widely accepted yet, often a substantial discount has to be given or other provisions made to close a sale. Currently SMES units are sold below cost (see Exhibit 16 – American Superconductor Corp. Segment Analysis 3/1997-3/2003E) and for the D-SMES units on order, the company entered into a repurchase agreement.

Since most of the HTS products are developed with a partner, the partner is the only buyer for a certain application. American Superconductor's success depends then on the success of the partner and the partner can exert substantial power on the company. The partner is usually a large firm and its survival will not depend on the success of the HTS product. This is not the case for American Superconductor.

4.3.4. *Rivalry amongst Existing Firms*

There is currently only one serious competitor for American Superconductor in the U.S., Intermagnetics General[29] (IGC). But there are a number of companies that have an HTS R&D program and can become competitors at any time (see Section 4.4.1).

Intermagnetics General Corporation, based in Latham, New York, has about $100 million of sales annually. IGC has two related product ranges: superconducting magnetic products (LTS and HTS) and refrigeration products.

Intermagnetics produces LTS wire, cable and tape (about 10% of sale) and LTS based magnets, primarily for medical MRI systems (45%) of sales. The company also produces, on a smaller scale, specialty magnet systems for research and industry. Other important products are radio frequency (RF) detector coils for MRI systems (10% of sales). The LTS technology provides a relatively stable revenue and profit stream.

Intermagnetics second product group is refrigeration systems. Its subsidiary APD Cryogenics, Inc. is able to deliver the full range of cooling equipment for LTS and HTS magnet systems. The company has some 600 employees.

Intermagnetics has many years of experience with LTS and HTS products. Unlike ASC it is profitable and does not need to rely on outside financing for its operation. Intermagnetics is engaged in R&D programs for SMES and HTS power cable.

4.3.5. *The Optimum Strategy*

Porter advises three generic strategies: cost leadership, differentiation and focus. The first two strategies are unattainable for the near future, leaving focus as the only viable alternative. Cost leadership and differentiation strategies address the whole market in the industry. But with most of its products still in the R&D phase American Superconductor can only address selected problems.

American Superconductor's products in existence and under development offer superior solution in selected areas:

- In power quality when the charging-recharging cycle is too fast for battery driven UPS
- For power cables when the current carrying capacity of underground cables must be increased without increases in the cable duct space
- For motors and generators when the size matters
- For transformers when size and environmental concerns matter

What makes superconducting power equipment valuable to its customers is therefore not the loss free transmission of electricity, as originally thought, but other benefits derived from superconducting technology. In the selected areas the company may be able to achieve cost leadership. In these areas it is also able to differentiate itself from competitors as a technology leader.

Long-term some of the niche markets that American Superconductor aims to serve may be enlarged. With more and more digital devices the demand for all types of power quality solutions, including SMES, is likely to increase. In addition, the company hopes that superconductor technology may be able to reduce the production cost of large motors by up to 40% since assembly becomes easier with smaller parts. If that is the case cost leadership could be achieved for large electrical motors in general. The same would be the case for electric generators.

However, the production costs of superconducting wire are substantially higher than the production costs of copper wire due to more expensive raw material and a more complicated production process. And it is likely that superconducting wire will never reach the cost of copper wire, not even when measured as cost per current carrying capacity. Overall cost leadership may therefore be no viable option in the future.

It is difficult to estimate how many successful products the company needs to survive. All products, however, share superconducting technology and progress in the wire and tape making will benefit all product lines. The company has also the option of enlarging its service business. Currently it offers assessments for power quality needs. This could go as far as offering alternative solutions or even an insurance against failures from power loss. For the near future is would certainly best to concentrate on its core HTS products.

4.4. RESULTS: VALUATION

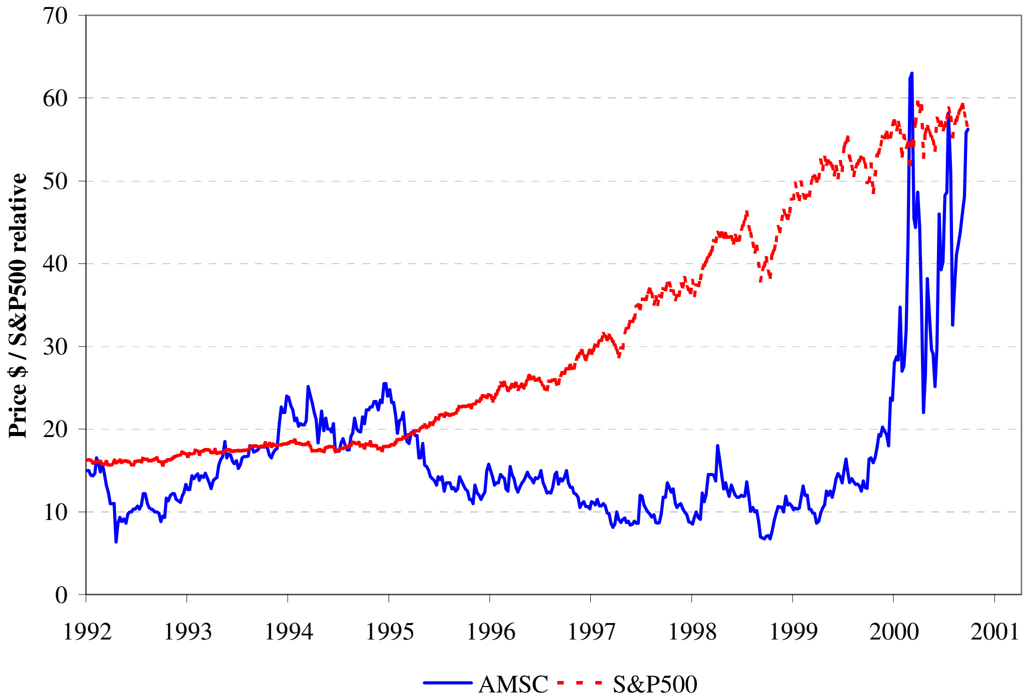
American Superconductor's share price has fluctuated widely over the years, both short-term and long-term (see Exhibit 6 – American Superconductor Share Price Relative to S&P500 Index 1992-2000). Apparently investors have difficulties valuing the company. The share price changed dramatically during the last two secondary offerings, probably through a heightened profile and the trading actions of banks involved in the offerings (stabilizing transactions and short sales)[31]. Furthermore, speculative waves have a significant effect on the stock price from time to time. During the last year, American Superconductor's stock price covered the range between $12 and $75.

A comparison with peer companies is impossible since there is no other comparable company. Comparisons with other technology companies are also difficult. The share prices of most of these companies have changed significantly over the last year, indicating that there are great uncertainties in valuing these companies. Little guidance can therefore be drawn from such comparisons.

Most promising appears to be a valuation based on the discounted free cash flow. Cash flow estimates can be made from potential market sizes, market penetration assumption, cash flow margin estimates and capital expenditure forecasts. All these assumptions have large uncertainties and it is prudent to err on the conservative side. The valuation model is based on the following assumptions:

1. The power quality market of $500 million doubles in 5 and triples in 10 years. This will be largely driven by an increase in digital equipment. The portion of this market addressable by SMES increases from 2% currently to 10% in 10 years. Assuming that Intermagnetics General and other Japanese or European companies will enter the market, American Superconductor's market share will fall from 100% to 30%.
2. The $5 billion worldwide power cable market grows at an annual rate of 3.5%, in line with the worldwide increase in electricity demand (see Exhibit 3 – World Electricity Consumption by Region 1990-2020E).

Exhibit 6 – American Superconductor Share Price Relative to S&P500 Index 1992-2000[32]



3. The $1 billion market for large motors (>1,000hp) and the $2 billion market for generators grow only slowly with 3% annually. If HTS technology proves successful in this application, prices for motors and generators are likely to fall. HTS products can address the whole market for large motors and generators.
4. The $1 billion market for large transformers (>10MVA) grows at 5% annually over the next 5 years. HTS products can address the whole market. ASC's partners will capture 30% of the HTS transformer market, ASC will contribute 20% of the product value.
5. We assume that ultimately about 1% of the power electronic converter market will be captured by American Superconductor.
6. There is currently no market for HTS fault current limiters. We assume that, beginning in 2005, 30% of the market is captured which reached $500 million in 2010.

7. No other revenue sources are considered. Currently the company receives about $10 million in contract revenue, largely for R&D contracts from the government. We assume that these sources will be reduced in the future. Such sources are, however, included in the short-term forecast in the Appendix, which is therefore slightly different from the valuation model.
8. We assume a terminal growth rate of 3% beginning in 2010. The HTS markets are then developed and growth rates will shrink.
9. We assume that all cash at hand (about $170 million) will be used up for capital expenditures. We also assume that the cash value of loss-carry forward of about $100 million will be used for capital expenditure. Therefore, cash at hand and the tax asset will not enter the valuation.
10. We assume that the free cash flow margin (free cash flow divided by revenue) will reach 10% in 2010. American Superconductor is still to a large extent an R&D company and will continue to need cash for R&D at the current level ($15 million annually) for several years. As production increases, more cash is needed for plant enlargement. For comparison, IBM's average free cash flow margin 1994-1999 is 9%, Intel's average free cash flow margin for the same period is 15%.
11. We use a discount rate of 6.5%, approximately the rate on 30-year Treasury bonds. The discount rate does not reflect any risk adjustment.

The valuation result for these assumptions is shown in Exhibit 7 – American Superconductor Corp. Valuation Model. We arrive at a value of $45 per share. This number, however, assumes success in all business segments to at least some extend. In addition, no risk premium is paid over U.S. Treasury bonds, something a prudent investor would refuse to do.

Some insight in the risk involved can be gained by varying some of the assumptions (see Exhibit 8 – Value per Share with Varying Discount Rate and Free Cash Flow Margin). The value per share is very sensitive to changes in the free cash flow margin and the discount rate. A cautious investor would therefore buy only at a substantial discount to the perceived likely value of $45 per share.

Exhibit 7 – American Superconductor Corp. Valuation Model

($ millions)	3/01E	3/02E	3/03E	3/04E	3/05E	3/06E	3/07E	3/08E	3/09E	3/10E	
Power quality											
Total market	500	625	750	875	1,000	1,100	1,200	1,300	1,400	1,500	
SMES share	2.0%	2.5%	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%	
ASC share	100%	100%	75%	50%	50%	30%	30%	30%	30%	30%	
Revenues	10	16	17	18	25	20	25	31	38	45	
Power cables											
Total market	5,000	5,180	5,360	5,550	5,740	5,940	6,150	6,370	6,590	6,820	
Pirelli HTD share	0.3%	0.5%	0.7%	1%	2%	5%	8%	12%	16%	20%	
ASC share of cables	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	
Revenues	3	5	8	11	23	59	98	153	211	273	
HTS motors											
Total market	1,000	1,030	1,060	1,090	1,120	1,150	1,180	1,220	1,260	1,300	
Reliance HTS share		0.3%	0.5%	1.0%	1.5%	2.0%	3.0%	5%	10%	12%	
ASC share of motors		30%	30%	30%	30%	30%	30%	30%	30%	30%	
Revenues	-	1	2	3	5	7	11	18	38	47	
HTS generators											
Total market	2,000	2,060	2,120	2,180	2,250	2,320	2,390	2,460	2,530	2,610	
ASC partner share				0.1%	0.5%	0.8%	1.0%	2.5%	5%	7%	
ASC generator share				30%	30%	30%	30%	30%	30%	30%	
Revenues	-	-	-	1	3	6	7	18	38	55	
HTS transformers											
Total market	1,000	1,050	1,103	1,158	1,216	1,276	1,340	1,407	1,478	1,551	
ASC partner share					0.3%	0.8%	1.0%	2.5%	5%	7%	
ASC transformer share					20%	20%	20%	20%	20%	20%	
Revenues	-	-	-	-	1	2	3	7	15	22	
Power electronics											
Total market	1,000	1,050	1,100	1,160	1,220	1,280	1,340	1,410	1,480	1,550	
ASC share	0.1%	0.1%	0.2%	0.5%	0.8%	1.0%	1.0%	1.0%	1.0%	1.2%	
Revenues	1	1	2	6	10	13	13	14	15	19	
HTS current limiters											
Total market					5	10	50	100	200	500	
ASC share					30%	30%	30%	30%	30%	30%	
Revenues	-	-	-	-	2	3	15	30	60	150	
Total revenues	14	23	28	38	68	110	172	272	414	610	Terminal
Expenses	(48)	(42)	(39)	(42)	(68)	(107)	(167)	(261)	(393)	(576)	Value
Free cash flow	(34)	(19)	(11)	(3)	-	2	5	14	33	61	1,794
Free cash flow margin	*-239%*	*-86%*	*-40%*	*-9%*	*0%*	*2%*	*3%*	*5%*	*8%*	*10%*	
Terminal growth rate	3.0%										
Discount rate	6.5%										
Net present value	901										
Number of shares	20m										
Value per share $	**45**										

Exhibit 8 – Value per Share with Varying Discount Rate and Free Cash Flow Margin

Discount	Free cash flow margin in 2010					
Rate	0%	5%	10%	15%	20%	25%
6.0%	(3)	26	56	86	115	145
6.5%	(3)	21	45	70	94	118
7.0%	(3)	17	38	58	79	99
7.5%	(3)	14	32	49	67	84
8.0%	(3)	12	27	42	57	72
8.5%	(3)	10	23	36	50	63

4.5. CONCLUSION

American Superconductor is transforming itself from a high-temperature superconductor R&D to a manufacturing company serving the electric power industry. Its business environment is changing rapidly due to deregulation in the electric power industry, increasing environmental concerns and a greater need for high quality electric power. The main forces the company has to reckon with are

- The bargaining power of suppliers, especially those of knowledge
- Threats from substitute products, primarily the conventional equipment it aims to replace, and
- The bargaining power of buyers, mainly its strategic partners

In this environment the company can find a viable strategy by focusing on particular needs, i.e. power quality applications with fast cycle times and power applications where size and environmental concerns matter.

The valuation returns a value of $900 million for the company or $45 per share. This number has to be further discounted if the success of certain product lines becomes questionable.

5. Evaluation of the Thesis Work

One of the first large-scale applications of superconductor technology was in large particle accelerators like Brookhaven's Relativistic Heavy Ion Collider[33] where I work. However, commercial applications of this technology are not yet wide spread and primarily limited to diagnostic tools like MRI. With the discovery of high-temperature superconductors in 1986, interest in the commercial use of superconductors renewed. Through my professional involvement in the use of superconducting technology I found it fascinating to evaluate the possible economic gains that can be made with this technology.

To evaluate a company's strategy and finally arrive at a value, the company has to be viewed from many angles. Information has to be collected and analyzed in non-numeric and numeric ways. So I profited from all the courses I took at the Harriman School so far: economics, operations management, accounting, finance, and e-commerce. These courses provided a solid basis. Especially useful were case studies in several of the courses were alternative company actions and their consequences were discussed freely. I would probably have benefited further from a strategy course.

Since almost everything that a company does, affects its value, a valuation must include a thorough analysis of many business aspects. It was this need for a comprehensive view that I found most interesting and challenging.

APPENDICES

A. SUPERCONDUCTIVITY

Superconductors are materials that can conduct direct current with 100% efficiency. This is different from most materials, which are either insulators, or conductors with some resistance. Resistance leads to electric energy loss when current flows through a conductor. Superconductors therefore allow a loss free energy transmission. Three conditions must be fulfilled before a superconductor looses all electrical resistance:

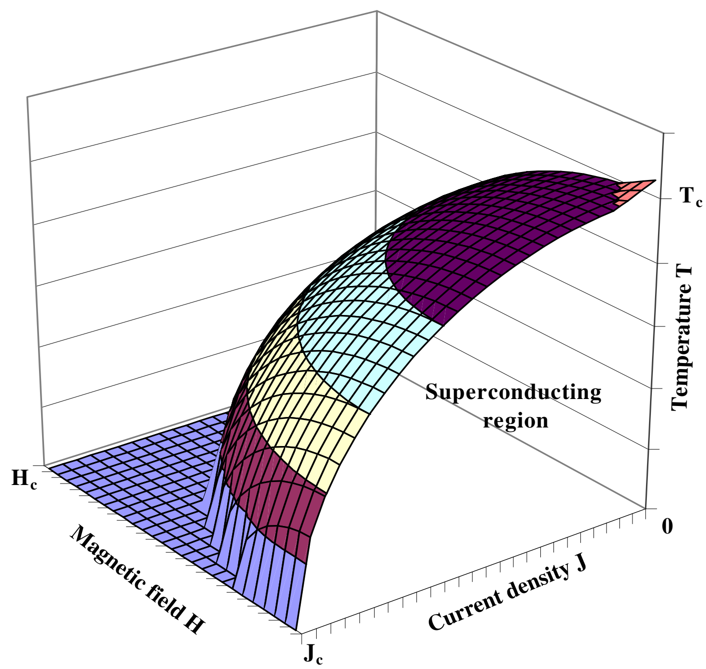
1. The temperature must be below a critical temperature $T_{c.}$
2. The current density (flow of current through a cross-section) must be below a critical density J_c.
3. The magnetic field to which the superconducting material is exposed must be below a critical field H_c.

This is illustrated in Exhibit 9 – Superconductivity exists only under the critical J-H-T surface. One distinguishes two broad classes of superconductors, low-temperature superconductors (LTS) and high-temperature superconductors (HTS). Low-temperature superconductors must be cooled to temperatures near the absolute zero (typically four Kelvin or minus 452 degrees Fahrenheit) for which liquid helium is used in most cases. High-temperature superconductors (HTS) can be cooled with liquid nitrogen (nitrogen becomes liquid at 77K or minus 322 degrees Fahrenheit). The cooling technology for HTS superconductors is significantly less complicated and more cost efficient than the cooling technology for LTS superconductors.

Heike Kamerlingh Onnes discovered superconductivity in pure metals, such as mercury, tin and lead, in 1911. Kamerlingh Onnes earned the Nobel Prize in physics in 1913 for his advancements in cooling technology that made the discovery of superconductivity possible. Until 1986 no materials were known with a critical temperatures above 23K (minus 418 degrees Fahrenheit). In 1986 Alex Müller and Georg Bednorz discovered a ceramic oxide with a critical temperature of 36K (minus 395 degrees Fahrenheit) which was one of a whole new class of superconducting materials. Müller and Bednorz also earned a Nobel Prize for their discovery. Today, superconductors with critical temperatures above

100K (minus 279 degrees Fahrenheit) are known. Commercial applications of high-temperature superconductors concentrate on only a few materials (see Appendix C.1.).

Exhibit 9 – Superconductivity exists only under the critical J-H-T surface



B. COMPANY HISTORY MILESTONES

Apr-1987	Incorporation in Delaware
Dec-1991	Initial public offering
Apr-1994	Second share offering
Feb-1996	"1995 Technology of the Year Award" from "Industry Week" magazine
Feb-1996	R&D program with Inco Alloys Intl. extended for manufacturing of metallic precursors (building blocks for HTS wire), total funding from Inco reaches $12 million
Mar-1996	200hp HTS motor tested by Reliance Electric, coil from ASC
Mar-1996	R&D agreement with Pirelli Cable for power cable development (ASC to receive $7.5 million from Pirelli Cable), Pirelli receives exclusive rights to ASC SC wires

Mar-1996	Strategic alliance with Electric Power Research Institute (EPRI) and two National Laboratories for the development of "coated conductor" HTS technology, a potentially cheaper manufacturing technology
Aug-1996	Demonstration of a 50m 3.3kA HTS power cable with Pirelli Cable, ASC delivered 6km of tape
Oct-1996	"1996 R&D 100 Award" by "R&D Magazine" for HTS wire and current leads
Nov-1996	Inco Alloy discontinues participation in R&D program for metallic precursors (loss of $1 million of funding)
Mar-1997	Demonstration of a 639kVA HTS transformer in Geneva
Mar-1997	Demonstration of a 8kJ SMES that can release up to 100A in less than a second
Apr-1997	$10 million investment from Electricité de France (EDF), the world's largest utility
Apr-1997	Acquisition of Superconductivity Inc. (SI), a producer of LTS SMES, for $9.4 million in stock, in addition $6.4 million in debt assumed
May-1997	Japanese Prime Minister's Science and Technology Agency Award for CEO Yurek
Jun-1997	Launch of LTS SMES product line, field testing begins on a chemical mixing unit
Aug-1997	Acquisition of Applied Engineering Technologies Ltd. (AET), a provider of cryogenic equipment, for $700,000, in addition $121,000 of debt assumed
Apr-1998	Third share offering, 3.5 million shares priced at $14
Jul-1998	Agreement with Lucent Technologies for cross licensing of HTS patents
Feb-1999	SMES product line extended by distributed SMES (D-SMES)
Nov-1999	ASC creates an electric motor and generator business unit
Mar-2000	Fourth share offering, 3.5 million shares priced at $62.50
May-2000	ASC to locate world's first commercial HTS wire manufacturing facility in Devens, Massachusetts
Jun-2000	ASC acquires Integrated Electronics, LLC, a producer of power electronic converters, for approximately $2 million in cash and stock
Jul-2000	1,000hp motor tested by Rockwell Automation, ASC delivered superconducting coil
Sep-2000	Shipment of HTS Wire to Pirelli for Detroit Edison Power Cable Project

C. PRODUCTS AND MARKETS

American Superconductor's core products are high-temperature superconducting wires and tapes. The company also integrates these wires and tapes into components for electric power equipment and end products.

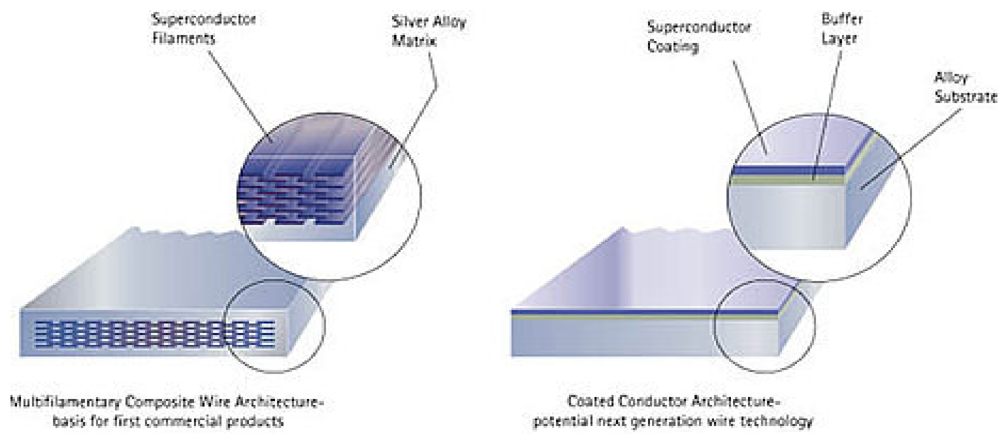
C.1. Superconducting Wire

High-temperature superconducting wire is American Superconductor's main product. Its production has been perfected over ten years. The company does not conduct any materials research. Instead, it tries to obtain patents for HTS materials and concentrates on the process of manufacturing superconducting wire in commercial quantities.

Superconducting wire can be produced in a number of ways[34]. In the company's principal technique a silver tube is filled with a precursor powder and sealed to form a billet. Through extrusion, wire-drawing, multifilamentary bundling and rolling the billet is deformed into a wire. The wire is then heat-treated to transform the precursor powder into a high-temperature superconducting material. The resulting composite structure consists of many fine superconducting filaments imbedded in a metal matrix. This composite structure is protected by a patent, owned by the Massachusetts Institute of Technology, and licensed exclusively to the company until 2010. The company's Westborough plant has produced a more than 1,000 km of HTS wire for demonstration and development purposes. The plant's current capacity is 500 km per year. ASC will invest $40 million to build a new plant in Devons, Massachusetts. The new plant is expected to begin full operation in 2002 with a capacity on 10,000 km of HTS wire per year.

SC wire and tape is only rarely sold separately in large quantities. One such instance would be deliveries for the magnet production of high-energy particle accelerators[35].

Exhibit 10 – The two most common HTS wire architectures



HTS Wire Architectures

Source: American Superconductor Corporation at www.amsuper.com

C.2. Superconducting Magnetic Energy Storage

The company's first application of superconductivity in the electric power industry is Superconducting Magnetic Electric Storage (SMES). In this application, a superconducting coil stores energy without loss and releases it in a short time, typically less than a second, when needed. Thus grid voltage drops of a short duration can be compensated and equipment that is sensitive to such drips can be protected. EPRI[36] estimates the cost of power disruption in the United States to be approximately $30 billion per year. SMES units address this concern and it is estimated that the market for power reliability solutions addressing voltage stability and low voltage transmission networks is currently $500 million in the U.S. and will double within five years.

Increasing demand will come from businesses for which the interruption of production or service causes large costs. Such businesses include semiconductor manufacturers, cellular phone providers, financial service providers, and the military. ASC's SMES units are currently the only ones commercially available. But several companies explore this technology, including Intermagnetics General[37] and Accel Instruments[38] in Germany. There is also a government-sponsored program in Japan. In addition, SMES competes with flywheels and uninterruptable power supplies (UPS), dynamic voltage restorers and static VAR compensators.

Currently the company's SMES units are built from low-temperature (LTS) superconductors with HTS leads (the transition pieces between the cold coil and the warm environment). SMES units can hold many Megajoules of energy, to be released over about one second. ASC's SMES units are usually shipped in a trailer, costing about $500,000 to $1 million per unit.

The company has two SMES product lines, PQ-SMES (power quality SMES) protects industrial equipment from power dips, D-SMES (distributed SMES) units are intended to stabilize a power delivery networks.

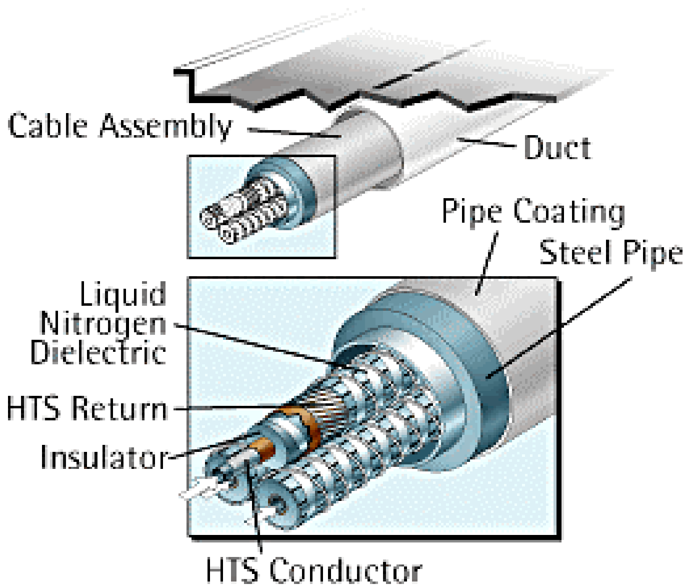
In March 2000, the company had 10 PQ-SMES units in operations and orders for another 4 units. In addition, 8 D-SMES units were on order. The company has a SMES distribution agreement with Caroline Power & Light [39]and a marketing and sales alliance for SMES with GE. A co-branded SMES product was launched with GE.

ESTIMATED MARKET SIZE : $500 million per year for power quality solutions
BEGIN COMMERCIALIZATION : 1997

C.3. Superconducting Power Cables

HTS wire can carry 100 times the current of a copper wire of the same dimension. Power cables made from HTS wire carry two to five times more current than conventional power cables of the same dimension. They are therefore ideally suited to replace power cables in urban areas where demand is rising and the installation of new conventional cables would require new cable conduits[40]. In the U.S. there are about 3,500 miles of underground transmission lines, worldwide an estimated 80,000 miles. About two thirds of the domestic lines are ripe for replacement. In addition, superconducting power cables are much lighter and cooled with liquid nitrogen, which is harmless when released into the environment. Conventional underground power cables are cooled with oil, which is more expensive than liquid nitrogen and requires additional environmental precautions. American Superconductor has a strategic alliance with Pirelli Cable[41], the world's largest manufacturer of power cables, for the development of HTS power cables. Pirelli Cable has the exclusive rights to ASC's HTS cables outside Japan while it supported the company's R&D efforts with more than $15 million over the years.

Exhibit 11 – Superconducting power cable



Source: American Superconductor Corporation at www.amsuper.com

The company has delivered approximately 18 miles of HTS wire to Pirelli to manufacture three 400-foot HTS power cables, to be installed in a substation of the Detroit Edison Company by the end of 2000. At a project cost of $5.5 million, the three HTS power cables will replace nine copper cables and transport 100 megawatts of power. The total weight of the HTS cables is 900 pounds, as compared to the approximately 18,000 pounds for the replaced copper wires. Meanwhile competitor Intermagnetics General[29] reported in January 2000 that Southwire[16] had installed three 100-foot HTS cables at its Carrolton, Georgia headquarters.

ESTIMATED MARKET SIZE : $5 billion per year
BEGIN COMMERCIALIZATION : 2001

C.4. Superconducting Motors and Generators

According to the U.S. Department of Energy 70% of the electric energy used by the manufacturing sector and 58% of all electricity generated in the United States is used by electrical motors. Large industrial motors with 1,000hp or more convert 30% of the generated electric energy in the U.S. Such motors are used for pumps, fans and compressors. Electrical motors in HTS technology would be only half the size and weight of conventional motors. Due to this fact HTS motors may be manufactured at up to 40% less cost than conventional motors. ASC's market research found that customers do not need higher operating efficiencies but want lower-priced motors. Nevertheless, a 10,000hp motor would allow for up to $100,000 savings in electricity costs annually. American Superconductor develops and manufactures HTS wires, rotor coils and cryocoolers for large industrial electrical motors. Together with Reliance Electric[42], a Rockwell Automation business, the company develops electrical motors with 1,000hp and 5,000hp ratings.

In 2000, Rockwell tested successfully a 1,000hp HTS motor, which will be installed in an industrial site later that year. The company also has a contract from the U.S. Navy for the development of a 33,000hp HTS motor for ship propulsion.

ESTIMATED MARKET SIZE : $1 billion per year (>1,000hp)
BEGIN COMMERCIALIZATION : 2001

While electric motors transform electrical in mechanical energy, generators transform mechanical in electrical energy. They are motors "in reverse" and essentially the same device. The successful development of a large electrical motor will therefore also benefit the development of an HTS generator. HTS generators would have the same benefits as HTS motors, i.e. smaller size and weight and less electrical losses. EPRI estimates that more than 1,000GW of new generating capacity are needed in the next 10 years, 175GW in the U.S. alone.

ESTIMATED MARKET SIZE : $2 billion per year (>30MW)
BEGIN COMMERCIALIZATION : >2001

C.5. Superconducting Transformers

Transformers are sited in substations and change the voltage level when electric energy is transported from one grid section to another. As other HTS products for the electric power industry, transformers are smaller, lighter and have less electric losses than conventional equipment. They are particularly well suited for urban areas where real estate is expensive. In addition, HTS transformers are submerged in liquid nitrogen, which is harmless to the environment. Conventional transformers are insulated and cooled with oil and special measures have to be taken to prevent spills. An HTS transformer has only 25-50% of the energy loss of a conventional transformer.

With its partners ABB and Electricidé de France (EdF), a 630kVA transformer was demonstrated in Geneva, Switzerland, in 1997. A 3-phase 10MVA HTS transformer demonstration was scheduled for 2000. ASC intends to develop a special HTS wire for transformers in the future. However, a funded R&D program with ABB and EdF was terminated in April 2000 to concentrate on short-term goals. The existing U.S. transformer market for the 10-100MVA devices is $260 million annually, $100 million for more powerful devices. The world market is expected to be 3 to 4 times larger and grows twice as fast (see Exhibit 3 – World Electricity Consumption by Region 1990-2020E).

ESTIMATED MARKET SIZE : $1 billion per year
BEGIN COMMERCIALIZATION : >2003

C.6. Other Products

ASC's SMES units use power electronic converters. The company acquired Integrated Electronics, a producer of power electronics converters, in 2000. It is estimated that about 20% of all power generated in the U.S. goes through power electronic converters. The company will concentrate on the high end of the power electronic market (>100kW).

ESTIMATED MARKET SIZE : $1 billion per year
BEGIN COMMERCIALIZATION : 2000

Stand-alone fault current limiters represent a new class of devices that will protect power grids from troublesome current surges that can cause costly outages and damage utility system components. Conventional copper-based equipment has inherent losses that can be prevented with HTS technology.

ESTIMATED MARKET SIZE : $3-7 billion in the next 15 years
BEGIN COMMERCIALIZATION : >2005

Other products include cooling systems, current leads, and specialty HTS magnets. The are likely to represent only a small percentage of the total expected revenue.

D. FINANCIAL STATEMENTS

Exhibit 12 – American Superconductor Corp. Consolidated Balance Sheet 3/1997-3/2003E

($000)	3/1997	3/1998	3/1999	3/2000	3/2001E	3/2002E	3/2003E
Cash and equivalents	585	1,842	24,969	126,918	31,518	33,268	39,318
Accounts receivable	3,071	2,992	4,099	7,317	8,817	10,317	11,817
Inventory	2,941	3,230	5,025	9,247	12,747	15,747	18,247
Prepaid expenses, other	729	545	538	809	1,009	1,209	1,209
Total current assets	7,325	8,609	34,631	144,291	54,091	60,541	70,591
PPE, gross	12,604	15,429	19,060	24,978	64,978	79,978	89,978
Accumulated D&A	(8,836)	(11,007)	(12,946)	(15,199)	(20,399)	(27,899)	(38,399)
PPE, net	3,768	4,423	6,115	9,778	44,578	52,078	51,578
Marketable securities	15,446	6,167	6,603	91,737	136,737	111,737	91,737
Other assets	42	352	781	3,108	3,108	3,108	3,108
Total non-current assets	19,256	10,942	13,499	104,623	184,423	166,923	146,423
Total assets	**26,581**	**19,551**	**48,130**	**248,914**	**238,514**	**227,464**	**217,014**
A/P and accrued expenses	4,284	3,333	4,172	6,339	8,839	11,339	12,839
Deferred revenue, other	2,723	217	-	371	371	371	371
Total current liabilities	7,007	3,550	4,172	6,710	9,210	11,710	13,210
Long-term debt, other	3,074	3,142	-	1,260	1,260	1,260	1,260
Total non-current liab.	3,074	3,142	-	1,260	1,260	1,260	1,260
Common stock	105	118	154	197	119	120	120
Additional paid-in capital	76,389	87,962	134,031	348,903	349,331	349,680	350,030
Deferred compensation	(25)	-	-	(530)	(330)	(130)	70
Deferred contract costs	(557)	(1,328)	(1,018)	(638)	(188)	312	862
Other income	(154)	-	10	(173)	727	1,627	2,277
Retained earnings	(59,257)	(73,892)	(89,218)	(106,816)	(121,616)	(137,116)	(150,816)
Total stockholders' equity	16,501	12,859	43,958	240,944	228,044	214,494	202,544
Total liab. and equity	**26,581**	**19,551**	**48,130**	**248,914**	**238,514**	**227,464**	**217,014**

Exhibit 13 – American Superconductor Corp. Consolidated Income Statement 3/1997-3/2003E

($000)	3/1997	3/1998	3/1999	3/2000	3/2001E	3/2002E	3/2003E
Contract revenue	6,867	9,274	9,238	10,439	12,350	14,850	20,850
Product sales and contracts	2,937	5,013	1,888	4,621	8,500	12,000	13,500
Rental and other revenue	747	842	131	54	150	150	150
Total revenue	10,551	15,129	11,257	15,113	21,000	27,000	34,500
Cost of revenue	(10,577)	(14,333)	(12,021)	(14,694)	(22,200)	(26,800)	(30,500)
Research and development	(8,477)	(8,641)	(10,409)	(13,206)	(13,500)	(14,000)	(14,500)
SG&A	(4,291)	(4,910)	(6,078)	(6,686)	(7,100)	(7,700)	(8,200)
EBIT	(12,795)	(12,755)	(17,251)	(19,473)	(21,800)	(21,500)	(18,700)
%age of revenue	*-121%*	*-84%*	*-153%*	*-129%*	*-104%*	*-80%*	*-54%*
Interest, net	821	543	1,912	1,871	7,000	6,000	5,000
Other expenses, net	(1,404)	(166)	13	4	-	-	-
Net earnings	(13,377)	(12,378)	(15,326)	(17,598)	(14,800)	(15,500)	(13,700)
%age of revenue	*-127%*	*-82%*	*-136%*	*-116%*	*-70%*	*-57%*	*-40%*
EPS (basic and diluted) $	**(1.27)**	**(1.06)**	**(1.01)**	**(1.11)**	**(0.75)**	**(0.78)**	**(0.67)**
CFPS $	**(1.09)**	**(0.88)**	**(0.88)**	**(0.97)**	**(0.48)**	**(0.40)**	**(0.16)**
BVPS $	**1.57**	**1.10**	**2.91**	**15.23**	**11.52**	**10.72**	**9.88**
Retained earnings	(13,377)	(12,378)	(15,326)	(17,598)	(14,800)	(15,500)	(13,700)
Average number of shares	10.498m	11.658m	15.132m	15.820m	19.800m	20.000m	20.500m

Exhibit 14 – American Superconductor Corp. Cash Flow Statement 3/1997-3/2003E

($000)	3/1997	3/1998	3/1999	3/2000	3/2001E	3/2002E	3/2003E
Net income	(13,377)	(12,378)	(15,326)	(17,598)	(14,800)	(15,500)	(13,700)
D&A	1,984	2,114	1,939	2,254	5,200	7,500	10,500
Deferred compensation	25	25	205	203	200	200	200
Deferred warrant costs	80	261	328	445	450	500	550
Other	872	284	-	-	-	-	-
Working capital changes							
- Accounts receivable	(1,343)	(462)	(1,108)	(4,968)	(1,500)	(1,500)	(1,500)
- Inventories	(974)	159	(1,795)	(4,222)	(3,500)	(3,000)	(2,500)
- Prepaid expenses, other	(74)	(206)	7	(271)	(300)	(300)	(350)
- A/P, accrued expenses	2,082	(1,877)	838	2,167	2,500	2,500	1,500
- Deferred revenue, other	626	(2,850)	(187)	1,631	1,500	1,500	1,500
Cash from operations	(10,098)	(14,930)	(15,098)	(20,359)	(10,250)	(8,100)	(3,800)
Purchase of PPE	(1,451)	(2,889)	(3,614)	(5,932)	(40,000)	(15,000)	(10,000)
Marketable securities	6,730	9,455	(442)	(85,303)	(45,000)	25,000	20,000
Other assets	(20)	(276)	(429)	(576)	(500)	(500)	(500)
Cash from investing	5,259	6,290	(4,486)	(91,811)	(85,500)	9,500	9,500
Issuance of stock	89	10,544	45,882	214,119	350	350	350
Change in debt	1,074	(639)	(3,171)	-	-	-	-
Cash from financing	1,163	9,905	42,711	214,119	350	350	350
Net increase in cash	3,676)	1,265	23,127	101,949	(95,400)	1,750	6,050
Cash, beginning of period	4,261	585	1,842	24,969	126,918	31,518	33,268
Cash, end of period	585	1,842	24,969	126,918	31,518	33,268	39,318
Available to reduce debt	(11,480)	(7,552)	26,741	187,251	(50,400)	(23,250)	(13,950)
Net cash (debt), beginning	24,438	12,957	4,867	31,572	217,395	166,995	143,745
Net cash (debt), end	**12,957**	**4,867**	**31,572**	**217,395**	**166,995**	**143,745**	**129,795**
Cash flow[1]	(11,394)	(10,265)	(13,387)	(15,344)	(9,600)	(8,000)	(3,200)
Free cash flow[2]	(11,549)	(17,820)	(18,712)	(26,291)	(50,250)	(23,100)	(13,800)
Distributable cash flow[3]	(4,839)	(8,640)	(19,584)	(112,170)	(95,750)	1,400	5,700

Exhibit 15 – American Superconductor Corp. Ratios 3/1997-3/2003E

	3/1997	3/1998	3/1999	3/2000	3/2001E	3/2002E	3/2003E
Liquidity Ratios							
Current ratio	1.0x	2.4x	8.3x	21.5x	5.9x	5.2x	5.3x
Quick ratio	0.6x	1.5x	7.1x	20.1x	4.5x	3.8x	4.0x
Activity Ratios							
Average collection period	106 days	72 days	133 days	177 days	153 days	139 days	125 days
Inventory turnover	3.6x	4.7x	2.2x	1.6x	1.6x	1.7x	1.9x
Fixed Asset turnover	2.8x	3.4x	1.8x	1.5x	0.5x	0.5x	0.7x
Leverage Ratios							
Equity ratio	62.1%	65.8%	91.3%	96.8%	95.6%	94.3%	93.3%
Net debt to equity	79%	38%	72%	90%	73%	67%	64%
Profitability Ratios							
Gross margin	0%	5%	-7%	3%	-6%	1%	12%
EBIT margin	-121%	-84%	-153%	-129%	-104%	-80%	-54%
Net profit margin	-127%	-82%	-136%	-116%	-70%	-57%	-40%
Cash flow margin	-108%	-68%	-119%	-102%	-46%	-30%	-9%
ROE	-81%	-96%	-35%	-7%	-6%	-7%	-7%

[1] Cash flow = Net income + D&A
[2] Free cash flow = Cash from operations + Purchase of PPE
[3] Distributable cash flow = Cash from operating + Cash from financing

Exhibit 16 – American Superconductor Corp. Segment Analysis 3/1997-3/2003E

	3/1997	3/1998	3/1999	3/2000	3/2001E	3/2002E	3/2003E
HTS							
Sales	7,174	11,566	9,748	11,611	13,500	16,000	22,000
EBIT	(10,860)	(10,085)	(12,005)	(13,684)	(16,200)	(16,000)	(18,700)
%age of sales	-151%	-87%	-123%	-118%	-120%	-100%	-85%
Assets		15,729	42,289	235,028			
ROIC		-64%	-28%	-6%			
SMES							
Sales	3,376	3,563	1,510	3,502	7,500	11,000	12,500
EBIT	(1,934)	(2,670)	(5,246)	(5,789)	(5,600)	(5,500)	-
%age of sales	-57%	-75%	-347%	-165%	-75%	-50%	0%
Assets		3,822	5,842	13,886			
ROIC		-70%	-90%	-42%			

BIBLIOGRAPHY

[1] American Superconductor Corporation www.amsuper.com

[2] P. Huber and M. Mills, "The Power Chip Paradigm", Power Report, inaugural issue, Gilder Group, 29 September 1999.

[3] U.S. Energy Information Agency www.eia.doe.gov (2000).

[4] "Impacts of the Kyoto Protocol on U.S. Energy Markets & Economic Activity", EIA Report SR/OIAF/98-03 (1998) http://www.eia.doe.gov/oiaf/kyoto/kyotorpt.html.

[5] "Analysis of the Climate Change Technology Initiative", EIA Report SR/OIAF/99-01 (1999) http://www.eia.doe.gov/oiaf/climate99/climaterpt.html.

[6] U.S. Energy Information Agency, International Energy Outlook 1999, www.eia.doe.gov (1999).

[7] M.L. Wald, "That Groan You Hear Is From the Power Grid", The New York Times, 23 April 2000.

[8] D. Gehl, Director Strategic Technology and Alliances at EPRI, talk given at Brookhaven National Laboratory on 15 March 1999.

[9] B.J. Feder, "Digital Economy's Demand for Steady Power Strains Utilities", The New York Times, 3 July 2000.

[10] M. Porter, "Competitive Strategy", Free Press (1998).

[11] Z. Bodie, A. Kane, and A.J. Marcus, "Investments", Irwin (1996).

[12] B. Graham and D. Dodd, "Security Analysis", McGraw-Hill (1934).

[13] B. Graham, "The Intelligent Investor", Harper Business (1973).

[14] Berkshire Hathaway Inc. www.berkshirehathaway.com

[15] General Electric Corporation www.ge.com

[16] Southwire Company www.southwire.com

[17] Balfour Beatty plc www.bicc.com

[18] Asean Brown Boveri www.abb.com

[19] Compagnie Financière Alcatel www.alcatel.com

[20] Sumitomo Electric Industries www.sei.co.jp

[21] Hitachi Ltd. www.hitachi.com

[22] Furukawa Electric Company www.furukawa.co.jp

[23] Fujikura Ltd. www.fujikura.co.jp

[24] Siemens AG www.siemens.com

[25] Vacuumschmelze GmbH www.vacuumschmelze.de

[26] Nordic Superconducting Technologies A/S www.ntc.com

[27] Oxford Instruments plc www.oxinst.com

[28] Minnesota Mining & Manufacturing Corporation www.3m.com

[29] Intermagnetics General Corporation www.igc.com

[30] EURUS Technology www.teameurus.com

[31] American Superconductor Prospectus for 3,000,000 shares of Common Stock, February 2000.

[32] Historic stock prices from quote.yahoo.com

[33] Relativistic Heavy Ion Collider www.rhic.bnl.gov

[34] American Superconductor Corporation, Annual Report and Report 10-K, 1997-2000.

[35] Discussions with members of the Superconducting Magnet Division at Brookhaven National Laboratory.

[36] Electric Power Research Institute www.epri.com.

[37] Intermagnetics General Corporation, Annual Reports and Reports 10-K 1997-2000.

[38] Accel Instruments GmbH www.accel.de

[39] Carolina Power & Light Energy Inc. www.cplc.com

[40] Telephone conversation with G. Yurek, CEO of American Superconductor, spring 1998.

[41] Pirelli SpA www.pirelli.com

[42] Reliance Electric Company www.reliance.com